Organic Carbon Content of the Green River Oil Shale
From Nuclear Spectroscopy Logs

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Total
Unconventional Resources
Oil shale, gas shale, oily shale

- Two dominant features:
  - Significant organic matter content
  - Low permeability

Objective: Quantify organic matter
Geochemical log data from Green River

- Conventional logs (Si, Ca, Fe) provide sedimentary lithology
- Na and Al logs can identify exotic minerals such as
  - Dawsonite NaAl(CO$_3$)(OH)$_2$
  - Nahcolite NaHCO$_3$
  - Analcime NaAlSi$_2$O$_6$·(H$_2$O)
- Carbon log will be used for TOC
Gamma Rays from Neutron-Nucleus Interactions

Neutron Source

Inelastic Microseconds
> 8 MeV

Capture Milliseconds
< 0.025 MeV
Elemental Capture Spectroscopy (ECS*) Tool

Logging Speed: 1800 ft/hr
Sampling Interval: 0.5 ft
Vertical Resolution: 1.5 ft
Borehole Fluid: All
Tool Diameter: 5.0 in
Length: 6.6 ft
Maximum Temp: 350°F
Maximum Pressure: 20k psi
Min Hole Size: 6.00 in

*Mark of Schlumberger
Reservoir Saturation Tool (RST*)

- Neutron Generator
- Shielding
- Near Detector
- Far Detector
- Inelastic Elements
- Si
- Ca
- C
- Counts

1-11/16 in RST-A

2-1/2 in RST-B
Conventional Reservoir Element Logs
Kerogen: Rock or Porosity?

When comparing core and log, data need to be on the same basis:

Rock Only or With Kerogen
Total Organic Carbon Log

• Elemental concentrations from Elemental Capture Spectroscopy (ECS*) Sonde
  – Si, Al, Ca, Fe, S, K, Na, Mg, Ti, Gd
• Carbon concentration from Reservoir Saturation Tool (RST*)
• Mineralogy computed from concentration logs
• Inorganic carbon computed from mineralogy
  – Calcite, Dolomite, Nahcolite, Dawsonite

\[ \text{TOC = Total Carbon – Inorganic Carbon} \]

ECS Silicon Log – correct for kerogen

With Kerogen weight percent
Rock Only weight percent
ECS Silicon Log Matches Core Data

With Kerogen weight percent
Rock Only weight percent
Core, with kerogen
Concentration Logs With Kerogen As Part of the Total Rock Weight
Total Carbon, Inorganic Carbon, and Total Organic Carbon
Total Organic Carbon Log

TOC, wt%

Depth, ft

150 foot depth interval
TOC Converted to Oil Yield

TOC to Fischer Yield
Core Fischer Assay

Independently derived AMSO correlation
Between TOC and Grade
Total Organic Carbon Log

- Capture spectroscopy logs produce accurate elemental concentrations
- Merging inelastic C produces accurate carbon log
- Geochemical interpretation for mineralogy and inorganic carbon
- TOC log based on geochemical measurements, not correlation
- Yield (gallon/ton) from TOC

![Graph showing counts and energy for capture and inelastic elements, as well as a TOC log chart.](image)